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TARDEC

---TECHNICAL REPORT---

THE NATION'S LABORATORY FOR ADVANCED AUTOMOTIVE TECHNOLOGY

WINNER OF THE 1994 FEDERAL QUALITY IMPROVEMENT PROTOTYPE AWARD

No. 13663

1994 Quality Improvement Prototype Award

TARDEC

VIRTUAL PROTOTYPING TOOLS CATALOG

MAY 1995

By Ronald R. Beck and Donna A. Croke
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Warren, MI 48397-5000

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This report is a catalog of the analytical simulation software packages available at the US Army Tank-automotive and Armaments Command and at its contractors for use in virtual prototyping, which allow the modeling and evaluation of different aspects of military vehicle performance. Each model is represented by a short description, uses, current features, current limitations, input requirements, available outputs, computer requirements, cost to use/maintain/develop and a point of contact.

Also included in the catalog are the physical simulation facilities or simulators used in the virtual prototyping process.

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Tank-Automotive Research, Development & Engineering Center
Development Business Group
Simulation, Test and Reliability Team

Modeling and Simulation

OVERVIEW

The U.S. Army Tank-Automotive Command (TACOM) Tank-Automotive Research, Development and Engineering Center (TARDEC) has created a supercomputer-based analytical and physical simulation system to reduce the time and high cost of conventional military vehicle prototype-based design and development. TARDEC's simulation capabilities may be divided into two major categories:

- Analytical Simulation
- Physical Simulation

Analytical simulation is supported by Computer-Aided Design Systems and High-Speed Graphics Workstations located throughout the Center. They are used by TARDEC's engineers and scientists for design, modeling, simulation and engineering analysis purposes. The computer-based analytical models are used increasingly for the simulation of most aspects of combat and tactical vehicle performance. Current emphasis is on the "Virtual Prototyping" of military vehicle systems and in particular the performance simulation and analysis of:

- Ride Dynamics and Controls
- Cross Country Mobility
- Truck/Trailer Stability
- Weapon Platform Stability
- Structural Integrity
- System Survivability
- Manufacturing

TARDEC has developed or contributed to the development of several mission specific comprehensive models suitable for performing the analytical activities listed above. In addition, commercial software packages are also used for finite element analysis.

TARDEC's Physical Simulation Laboratory (PSL) System consists of man and hardware-in-the-loop Motion Base Simulators. A Ride Motion Simulator and a Crew Station/Turret Motion Base Simulator are used to evaluate gunner and driver displays and controls associated with man/machine interaction dynamics issues under simulated ride dynamics conditions. TARDEC's full-scale Motion Base Simulators are capable of "shaking" complete combat and tactical vehicle systems weighing up to 40 tons. The purpose of the Physical Simulation Laboratory is threefold:

- To validate analytical models.
- To address man-in-the-loop issues.
- TO determine failure points of a vehicle system or subsystem

Physical Simulations conducted in the laboratory offer accelerated test schedules, repeatable test conditions and, therefore, are often more useful than more expensive, time consuming field tests. These laboratory simulations also allow the engineer to collect data which, otherwise, would be difficult or impossible to obtain.

In addition to the PSL, TARDEC's Vehicle Electronics (VETRONICS) business area has a Simulation Facility called the Vetronics Simulation Facility (VSF) used for the rapid prototyping and evaluation of crewstation and vehicle concepts.

Why the emphasis on simulation? In general, simulation allows:

- the quantitative evaluation of vehicle performance without building hardware,
- the exploration of many design excursions/ideas,
- the examination of many environmental and operational scenarios (some of which would be dangerous to execute at a proving ground),
- saving considerable time and money in the development and assessment process, and
- TARDEC to be a smarter buyer.

The overall thrust is to have modeling and simulation an integral part of combat and tactical vehicle acquisition process. TARDEC's simulation tools are used throughout a system's life cycle. Additionally, efforts are underway to identify how these tools can also be an integral part of testing and evaluation.

GENERAL PURPOSE HARDWARE AND SOFTWARE ASSETS

The Tank-Automotive Research, Development & Engineering Center (TARDEC) is well equipped to employ complex simulations. One of the Army's Cray-2 supercomputers is located at TACOM. In particular, TARDEC's General Purpose Scientific & Engineering (S&E) Hardware and Software Assets are described below:

Hardware

Cray Research, Inc Cray-2 Vector Supercomputer: Supports TARDEC, Army, DoD, Industrial, and Academic users. As part of the larger Army/DoD high performance computing (HPC) topology this asset is the key component of TARDEC's general S&E and HPC computing capabilities. This asset performs extremely complex calculations with large memory, storage, and speed requirements.

Silicon Graphics, Inc (SGI) Workstations: Supports TARDEC users. TARDEC has installed and supports a very large distributed networked configuration of advanced workstations. These SGI workstations are installed in desk-side, computer room, and workstation room environments and consist of practically all of SGI's product offerings - small to very large.

Digital Equipment Co (DEC) computers: Supports TARDEC users. DEC assets are centralized for the purpose of general purpose S&E computing, networking, motion base simulation, and Cray-2 interface applications. These DEC assets consist of small imbedded and large mainframe-class configurations.

Intergraph, Inc workstations: Supports TARDEC users. Intergraph workstations and associated peripheral devices are installed in three large scale computer aided design workstation enclaves. Recent advances in Intergraph's architecture permit their software to run on SGI and other Unix-based platforms available within TARDEC.

Sun Microsystems, Inc workstations: Supports TARDEC users. Sun workstations are installed in distributed desk top environments. They are networked with the other TARDEC assets described above. These Sun assets, generally, support general S&E computing requirements.

Apple Macintosh & DOS PC systems: Supports TARDEC users. Virtually every TARDEC associate has their own dedicated Macintosh and/or PC system to use. Applications include office automation as well as S&E. Via the TACOM-wide Local Area Network, TARDEC users can perform resident computations and exchange S&E data - both tabular and graphics - with practically anyone. The Macintosh assets are the preferred platform for high-end desktop S&E computation.

Advanced S&E graphics & visualization systems: Supports TARDEC users. TARDEC's S&E graphics & visualization assets interface directly with virtually all of the above described assets. Visualization is directly tied to S&E and HPC requirements. Capabilities range from desktop to laboratory-based still graphics, computer generated imagery, and studio-class video production and editing.

Dedicated S&E high speed networking: Supports TARDEC (directly) and offsite (indirectly) users. TARDEC has devised, installed, and operates its own dedicated high speed networking satisfying the requirements of advanced S&E and HPC computing. This networking also interfaces to external networks allowing offsite users access to TARDEC hardware assets and facilitating TARDEC access of external S&E and HPC resources.

Software

Commercial off-the-shelf software assets available and accessible by TARDEC and offsite users can be generalized according to the S&E discipline they support:

Structural Analysis: Various finite element modellers, solvers, and post processors used to analyze vehicle component parts, subsystems, and complete systems.

Dynamic Simulation: Pre-processors, solvers, and post processors used to depict and analyze complete system performance capabilities.

Computational Fluid Dynamics: Modellers and solvers used to analyze fluid flow and thermodynamics problems.

Software Engineering: Compilers, data base structures, graphical user interfaces, and networking tools which simplify the design, development, and integration of high power, user-friendly S&E software products and tools.

Visualization: Libraries, interfaces, and drivers for high end S&E visualization, production, and analysis (including computer generated imagery capabilities).

Miscellaneous: Small-scale (relatively speaking) software tools installed in the desktop environment for general S&E problem solving (controls modelling, basic engineering, mathematics, and statistics).

MISSION SPECIFIC SOFTWARE

The following pages summarizes TARDEC's analytical simulation packages and physical simulator assets. TARDEC's point of contact in this regard is Dr. Ronald R. Beck, Business Group Leader for Simulation or Mr. Dennis Calbeck. (Internal mailing symbol is AMSTA-TR-X) Telephone: Commercial (810) 574-6228 or DSN 786-6228.

ACRONYMS AND ABBREVIATIONS

DYNAMICS AND CONTROL

DADS	Dynamic Analysis and Design System
SOVAS	Symbolically Optimized Vehicle Analysis System
VRIDE	Vehicle Cross-Country Ride Evaluation & Simulation Package
MATLAB/ SIMULINK	Commercially Available Software Package
MATRIXx/ SystemBuild	Commercially Available Software Package

MOBILITY

NRMM II	Nato Reference Mobility Model II
OBS78B	Obstacle Crossing Module
VEHDYNII	Vehicle Dynamics Model

STRUCTURAL ANALYSIS

ABAQUS Code	Commercial Multi-Purpose Finite Element
PATRAN	Pre and Post Processor for FEA Package
P-FATIGUE	Commercial Computer Code for Predicting Durability
PINSTRESS	Track Pin Stress Simulation

SURVIVABILITY

ADRPM	Acoustic Detection Range Prediction Model
ARTM	Acoustic Requirements Translation Model
PRISM	Physically Reasonable Infrared Signature Model
RANES	Radiated Noise Estimation Software
TRACK	Radar Cross Section Simulation System
TTIM	TACOM Thermal Image Model
XPATCH	Radar Cross Section Simulation System

VEHICLE SUBSYSTEM EVALUATION TOOLS

AdvanSIM-1076	Digital SImulation Software
C SPICE	Analog Simulation Software
KIVA-II	Combustion Simulation Code
MISGUIDE	3-D Dynamic Simulation Code
TRACKDRIVE	Dynamic Track Simulation
TRACKDYNE	Dynamic Track Simulation

SYSTEMS AND COST

CASTFOREM	Combined Arms and Support Task Force Evaluation Model
DSAM	Distribution System Analyzer Model
GROUNDWARS	
MEL	Maintenance Expenditure Limit Model
MSM	Management Strategy Model
TDP	Technical Data Package
WARCAMpc	Warranty Cost Analyses Model

MANUFACTURING

Virtual Factory Simulation Software

SIMULATORS

CS/TMBS	Crew Station/Turret Motion Base Simulator
PMBS	Pintle Motion Base Simulator
RMS	Ride Motion Base Simulator
VSF	Vetronics Simulation Facility

ANNEX A

DYNAMICS AND CONTROL

DYNAMIC ANALYSIS AND DESIGN SYSTEM (DADS)

DESCRIPTION

DADS is a commercial multipurpose model that simulates the dynamic response of a wide variety of mechanical systems. DADS assumes that a mechanical system can be modeled as a system of discrete bodies interconnected with joints and force elements. DADS can also model control and hydraulic systems. The DADS program is currently being used to model the dynamic response of military tracked and wheeled vehicle systems.

USES

DADS is an engineering model used to determine the resulting dynamic response of a mechanical system.

CURRENT FEATURES

DADS features the following capabilities:
A library of joint, force, control elements.
Capability to model flexible bodies
A simple preprocessor is available for quick data entry.
A tire model is available for full scale vehicle simulation.
User supplied FORTRAN subroutines can be added to enhance program capability.

CURRENT LIMITATIONS

DADS has the following limitations:
Slow execution speed on small computers.
Limited pre and post processing capability.
Limited control and hydraulic modeling capability.
Limited track modeling capabilities in regards to track/soil interfaces.
Compliant/impact dynamics modeling capabilities for hull/turret interactions.

INPUT REQUIREMENTS

The following information is required to assemble a DADS simulation model:
The mass, inertia, and initial configuration of each body in the system.
The force vs. deflection and force vs. velocity characteristics of each force element.
Connectivity and dynamic description of each control or hydraulic system to be interfaced with the model.

In the case of a vehicle simulation, tire model parameters, terrain contours and powertrain description.
In the case of a flexible element simulation, mode shapes from a NASTRAN or ANSYS Finite Element Analysis are required.

AVAILABLE OUTPUTS

The DADS programs generates the following output:
The position, velocity and acceleration time histories for each body.
The joint and spring force time histories.
The control state variable and hydraulic system pressure time histories.
Animated graphical output is available with the appropriate post processing software

COMPUTER REQUIREMENTS

DADS can currently be operated on the CRAY-2, VAX, Sun and Silicon Graphics computers.

COST TO USE/DEVELOP/MAINTAIN

$5K/year (small engineering workstation) to $23K/year (Cray Supercomputer) depending on the type of computer and analysis desired.

POINT OF CONTACT

U.S. Army Tank-automotive and Armaments Command, ATTN: AMSTA-TR-X, Mr. Kevin Denton, Warren, MI 48397-5000, AC (810) 574-8167, DSN 786-8167

Symbolically Optimized Vehicle Analysis System (SOVAS)

DESCRIPTION

To address the critical need of accounting for the operator's influence on system performance (i.e., operator-in-the-loop simulations/simulators) while increasing the resolution of the vehicle system simulation models, TARDEC researchers are developing a new simulation methodology called Symbolically Optimized Vehicle Analysis System (SOVAS). Using SOVAS, they are creating high-resolution vehicle dynamic simulations capable of running in near realtime on Silicon Graphics workstations with interactive operator control. Another important aspect of this research is to insure automated procedures for rapid model development and minimizing the need for hands-on optimization of the interactive models. These models are being used experimentally in some vehicle evaluations and are being incorporated into a reconfigurable vehicle simulator architecture to support TARDEC's motion-base simulators. Both tracked and wheeled vehicles have been modeled using this methodology.

USES

Vehicle system and component subsystem dynamics research, realtime simulation development, taccident reconstruction, intelligent controls design and acquisition.

CURRENT FEATURES

Will give general users the ability to execute high resolution vehicle simulation models in real time on high-end Iris graphic computers. Designed to generate highly optimized computer code. Symbolic and numerical equation preprocessing procedures are applied to substantially reduce algorithm run-time operations count without sacrificing model accuracy. The SOVAS methodology will rely heavily on the powerful symbolic equation manipulation. Considerable progress has been made toward developing SOVAS into a general purpose methodology which will substantially reduce its dependency on a user's background in numerical methods and vehicle design.

CURRENT LIMITATIONS

Many of the optimization procedures used in SOVAS to achieve real-time simulation capability are still in experimental and developmental stages. Successful application of SOVAS currently requires considerable knowledge of the basic

underlying theory and a lot of manual effort to achieve the best results. This is primarily because the various classes of vehicle systems may have substantially different topological and kinematic structures which may require radically different optimization procedures to achieve best algorithm performance. It is emphasized, however, that SOVAS is not intended for the average user. Engineers within AMSTA-TR-X will generate the optimized models and install them in vehicle model libraries on workstations.

INPUT REQUIREMENTS

The following items are essential for establishing comprehensive computer-based vehicle models of systems of sufficient resolution to make reliable and accurate simulations of their dynamic responses under various operating conditions:

a. Drawing in 3 dimensions showing locations (attachment points) of:

(1) Chassis, payload and other major component center of gravity locations.

(2) Suspension system components (to include as applicable), springs (coil & leaf), air-bags, axles, trailing arms, torsion bars, panhard bars, torque rods, walking beams, shocks, chains, etc.

(3) Steering systems (where applicable).

(4) Tires.

(5) Brake Systems.

(6) Jounce and rebound stop locations and clearances.

(7) Vehicle Hitch Point.

(8) Detailed schematics of any other kinematics systems involved in the control of any systems not mentioned which significantly influence vehicle dynamics.

b. Other information to include:

(1) Suspension force/deflection curves for leaf-spring, coil spring or air suspension. Torsion bar spring rate for trailing arm suspension.

(2) Auxiliary suspension roll stiffness and roll center.

(3) Allowable suspension jounce and rebound travel.

(4) Jounce and rebound stop stiffnesses.

(5) Shock absorber force/velocity relationships.

(6) Vehicle center of gravity and principal moments of inertia of sprung and unsprung masses of all major components in all three dimensions.

(7) Brake information - output torque at wheel as a function of applied load to brake.

(8) Other unique features of the chassis, suspension, braking, or steering (if applicable) systems that should be included in the high-resolution models to accurately represent the system. For example, suspension self-leveling mechanisms.

The above paragraphs are examples of data required to develop vehicle sub-system models. Data requirements will be worked out on individual jobs on a model-by-model basis.

AVAILABLE OUTPUTS

The post processor allows state variables to be plotted and, when supplied with geometrical outline descriptions of the bodies comprising the system, can generate three dimensional representations on a graphics screen for visual interpretation.

COMPUTER REQUIREMENTS

High-end workstations or mainframe computers (including supercomputer platforms).

COST TO USE/DEVELOP/MAINTAIN

Methodology is still under development and modeling and maintenance costs (as such) are determined based on the complexity of the project being investigated.

POINT OF CONTACT

US Army Tank-automotive and Armaments Command, ATTN: AMSTA-TR-X, James L. Overholt, Warren, MI 48397-5000, AC (810) 574-8969, DSN 786-8969.

VRIDE

DESCRIPTION

VRIDE is a vehicle dynamics cross-country ride and vibration evaluation and simulation package. Vehicle pre- and post-processors are available for defining the vehicle configuration and tailoring the simulation output to fit the user's specific requirements. Engineering simulators.

USES

Vehice ride dynamics.

CURRENT FEATURES

Includes pitch and yaw
Simple to use pre-processor for data input
Flexible post-processor to investigate vehicle motion time histories
Model is well validated for VRIDE values
Well documented mature model
Nonlinear tire model
Good terrain library exists

CURRENT LIMITATIONS

Does not include vehicle roll
Uses point contact tire model
Does not include track effects

INPUT REQUIREMENTS

Vehicle Geometry
Mass and Inertia Properties
Suspension System Characteristics
Desired Terrain Scenario

AVAILABLE OUTPUTS

Driver limited vehicle speed
Cargo limited vehicle speed
Suspension induced acceleration
environment of any vehicle component

COMPUTER REQUIREMENTS

Operational on TACOM's Cray-2.

COST TO USE/DEVELOP/MAINTAIN

Use costs (analyst man years) are paid by the customer organization for the study being performed.

POINT OF CONTACT

U.S. Army Tank-automotive and Armaments Command, ATTN: AMSTA-TR-MTS, Mikell Eiler, Warren, MI 48397-5000, AC (810) 574-6376, DSN 786-6376

MATLAB/SIMULINK

DESCRIPTION

Matlab is a commercially available software package which integrates matrix manipulations, numerical and controls analysis, signal processing and high resolution graphics visualization into an easy-to-use environment where problems and solutions are expressed just as they would be written mathematically. Matlab also consists of an underlying programming language structure which allows the user to author software to perform complex dynamic system simulations and tasks. Matlab is currently being used in a variety of projects including; developing efficient decomposition algorithms for computational dynamics programs; developing fuzzy logic based control systems for HMMWV active suspension designs and creation of intelligent decision aide tools for the Virtual Prototyping Process.

USES

Matlab is primarily used for simulating and analyzing complex dynamic systems and for designing control systems to achieve desired behavioral responses.

CURRENT FEATURES

Matlab currently comes standard with the following features;
Ability to multiple matrices and/or vectors with a single command.
Most standard linear algebra routines are also incorporated in the core package.
Over 500 standard mathematical functions and routines.
Can be used as a scientific programming environment.
Logic programming structures such as "if" and "while" branches are incorporated.
A graphics environment that is compatible with the command portion of Matlab/Simulink.
A Graphics Users Interface (GUI) environment for Matlab command portion.
A block diagram, simulation-based environment (i.e. Simulink) integrated with Matlab.
Simulink contains several numerical DAE solvers including Runge-Kutta and Stiff Gear.
Add on Toolboxes containing routines specializing in specific field (e.g. Optimization Toolbox).
Capability to inport compiled FORTRAN or C code into Matlab/Simulink programs.

CURRENT LIMITATIONS

Matlab/Simulink does emphasis macro-modeling (e.g. leaf spring suspensions or dc-motors); the systems and subsystems being modeled and/or analyzed must be programmed using mathematical constructs (i.e. differential, algebraic and difference equations, array tables, etc.) provided by the user.

INPUT REQUIREMENTS

Matlab/Simulink requires that mathematical expressions, such as differential equations and block diagrams be either provided for or developed by the user. This is necessary to develop high resolution dynamic simulations. If the user is only interested in using Matlab/Simulink for "simple" arithmetic operations and matrix manipulations, the user need only supply the variable in question.

AVAILABLE OUTPUTS

The user is free to choose the output variables required to perform the necessary task. This is one of the major strengths of Matlab/Simulink; the ease of selecting and configuring the outputs from either simple mathematical calculations or highly nonlinear dynamic simulations.

COMPUTER REQUIREMENTS

Matlab/Simulink can be ran on several platforms including PCs (Mac and DOS based machines), workstations (e.g SGI, Sun and DEC) and supercomputers (Cray).

COST TO USE/DEVELOP/MAINTAIN

The cost ranges from $4K for a PC (one time cost) to as much as $180K initial cost for a Cray version with a yearly maintanence of $15K.

POINT OF CONTACT

U. S. Army Tank-automotive and Armaments Commands, Attn: AMSTA-TR-X, Mr. James L. Overholt, Warren, MI 48397-5000, (810)-574-8969, DSN 786-8969

MATRIXx/SystemBuild

DESCRIPTION

MATRIXx/SystemBuild is a commercially available software package which integrates matrix manipulations, numerical and controls analysis, signal processing and high resolution graphics visualization into an easy-to-use environment where problems and solutions are expressed just as they would be written mathematically. MATRIXx/SystemBuild contains a simulation environment which allows the construction of dynamic systems simulation through the use of "drag and drop" icons used in a block diagram representation. MATRIXx/SystemBuild also consists of an underlying programming language structure which allows the user to author and augment software to perform complex dynamic system simulations and tasks. MATRIXx/SystemBuild is currently being used in a variety of projects including; developing efficient decomposition algorithms for computational dynamics programs; developing fuzzy logic based control systems for HMMWV active suspension designs and creation of decision aide tools for the Virtual Prototyping Process.

USES

MATRIXx/SystemBuild is primarily used for simulating and analyzing complex dynamic systems and for designing control systems to achieve desired behavioral responses.

CURRENT FEATURES

MATRIXx/SystemBuild currently comes standard with the following features;
Ability to multiple matrices and/or vectors with a single command.
Most standard linear algebra routines are also incorporated in the core package.
Over 500 other standard mathematical functions and routines.
Can be used as a scientific programming environment.
Logic programming structures such as "if" and "while" branches are incorporated.
A graphics environment thatís compatible with the command portion of MATRIXx.
A Graphics Users Interface (GUI) environment for Matlab command portion.
A block diagram, simulation-based environment (i.e. SystemBuild) integrated with MATRIXx.
Simulink contains several numerical DAE solvers including Runge-Kutta and Stiff Gear.
Add on Toolboxes containing routines specializing in specific field (e.g. Optimization Toolbox).
Capability to import compiled FORTRAN or C code into MATRIXx/SystemBuild programs.

CURRENT LIMITATIONS

MATRIXx/SystemBuild does not emphasis macro-modeling (e.g. leaf spring suspensions or dc-motors); the systems and subsystems being modeled and/or analyzed must be programmed using mathematical constructs (i.e. differential, algebraic and difference equations, array tables, etc.) provided by the user.

INPUT REQUIREMENTS

MATRIXx/SystemBuild requires that mathematical expressions, such as differential equations and block diagrams be either provided for or developed by the user. This is necessary to develop high resolution dynamic simulations. If the user is only interested in using MATRIXx/SystemBuild for "simple" arithmetic operations and matrix manipulations, the user need only supply the variable in question.

AVAILABLE OUTPUTS

The user is free to choose the output variables required to perform the necessary task. This is one of the major strengths of MATRIXx/SystemBuild; the ease of selecting and configuring the outputs from either simple mathematical calculations or highly nonlinear dynamic simulations.

COMPUTER REQUIREMENTS

MATRIXx/System Build can be ran on several platforms including PCs (Mac and DOS based machines) and workstations (e.g. SGI, Sun and DEC).

COST TO USE/DEVELOP/MAINTAIN

The cost ranges from $9K for a PC (one time cost) to as much as $75K (core program plus three toolboxes) initial cost for a DEC5000 workstation version with a yearly maintenance of $5K.

POINT OF CONTACT

U. S. Army Tank-automotive and Armaments Commands, Attn: AMSTA-TR-X, Mr. James L. Overholt, Warren, MI 48397-5000, (810)-574-8969, DSN 786-8969

ANNEX B

MOBILITY

NATO REFERENCE MOBILITY MODEL
(NRMM II)

DESCRIPTION

NRMM is a large scale digital simulation which predicts the on-road and cross-country performance of a vehicle in a global sense. The measure of performance is speed-made-good and percent of an area denied due to immobilizations. The second edition, NRMM II, is now available.

USES

NRMM is used in the development of requirements documents (ORD's, RFP's), to support COEA's, as an evaluation tool in support of SSEB's and to support mobility studies of customers such as the PEO-ASM, PEO-CS.

NRMM is an engineering model (constructive type) which marries the engineering characterization of the vehicle (powertrain, running gear, suspension, mass and inertial properties and geometry) with the engineering characterization of the terrain (slopes, soil strength, obstacle geometry, surface roughness, vegetation density). It is an analytical simulation model which predicts the vehicle's maximum attainable speed cross-country and on-road for a specified geographic region and environmental condition (wet season, rainfall, snow) and defines within the geographic region areas of immobilizations and the reasons for such.

NRMM is used as a preprocessor input model for Wargaming models. It ascertains the maximum automotive performance of a vehicle traveling cross-country and on-road.

CURRENT FEATURES

Wheeled or Tracked Vehicles
Prime Movers or Trailers
(some restriction)
Sensitive to Environment:
  Seasons, Weather, Shallow Snow
Variety of Terrain Scenarios:
  Western Europe, Middle East
  Road Wet, Sand Scenario
Diagnostics
Measured Subsystem Data Replacement
Subsystem Performance
Central Tire Inflation
Large Data Base
Strictly Managed
Vehicle Data Development Program

Side slope module
  Expanded soil algoritjms
  Extended user options (e.g., CTIS)

CURRENT LIMITATIONS

Two Dimensional Simulation
No Wet Linear Features (e.g. rivers)
No Deep Snow
Steady State Powertrain Simulation
No Electric Drive
No Turbine
Only Mechanical/Hydromechanical
Transmissions
Trailers Restricted to Two Axles
No Steering
No Sev
Vehicle Dynamics Limited to Small Angle, Pitch Plan Motion

INPUT REQUIREMENTS

Vehicle Geometry
Chassis and Suspension Masses and Inertias
Suspension Characteristics
Power Train Characteristics and Performance
Desired Terrain and Scenario

AVAILABLE OUTPUTS

Tactical Levels of Mobility:
  Speed Profile
  Percent Area Denied
Diagnostic Outputs of:
  Reasons for NO-GO
  Limiting Speed Factors
Subsystem Performance:
  Powertrain Performance
  Gradeability, Acceleration
  Obstacle Negotiation
  VCI
  Ride Quality

COMPUTER REQUIREMENTS

Operational on TACOM's CRAY-2 Supercomputer

COST TO USE/DEVELOP/MAINTAIN

NRMM is a mature model and thus does not have any development costs associated with it. Usage costs can be quoted in terms of

man-months to perform an analysis. It requires 1.5 man-months to assemble data, execute the stand alone ride quality and obstacle crossing modules, analyze and report on results. Excursions for variants of a given vehicle configuration require 2 man-weeks per variant.

Computer costs vary depending upon the machine on which NRMM is mounted. At TARDEC, NRMM is mounted on a CRAY-2 and computer costs run roughly $500/hr. It requires less than an hour of CPU time to execute all of the modules of NRMM per vehicle.

Maintenance costs are quoted on an annual basis and require $50K per year.

POINT OF CONTACT

U.S. Army Tank-automotive and Armaments Command,
ATTN: AMSTA-TR-MTT, Mr. Peter Haley, Warren, MI 48397-5000
AC (810) 574-8633, DSN 786-8633

OBS78B

DESCRIPTION

OBS78B is the obstacle crossing module of NRMM which determines the undercarriage clearance and force history of the vehicle as it traverses a mound or trench type obstacle. It is a stand alone module. The clearances, average and maximum forces to negotiate an obstacle are used as part of the input to the main module of NRMM vehicle data set.

USES

OBS78B is a stand alone module of the NATO Reference Mobility Model (NRMM). Its uses are the same as NRMM.

OBS78B is an engineering model (constructive type) which is used to develop the obstacle crossing performance of a vehicle. The geometry engineering characterization of the vehicle (undercarriage clearance contour) is defined and negotiation of mound and trench type obstacles determined. This information is then used within the main module of NRMM to predict obstacle nergotiation over the geographic regions within the NRMM terrain data bases.

CURRENT FEATURES

Wheeled or Tracked
Single, Double Axle Trailers
Strictly Managed
Vehicle Data Development Program

CURRENT LIMITATIONS

Two Dimensional
Limited to:
- Two Bogied Prime Mover
- Single Bogie Trailer
- Statics Model
- No Track Tension
- Dry Feature

INPUT REQUIREMENTS

Vehicle Geometry
Sprung Mass Location
Suspension Type
Stylized Mounds and Trenches

AVAILABLE OUTPUTS

Clearance, Average and Maximum
Forces
Spatial History

COMPUTER REQUIREMENTS

Operational on TACOM's CRAY-2 Supercomputer.

COST TO USE/DEVELOP/MAINTAIN

OBS78B, as a stand alone module of NRMM, is a mature model and thus does not have any development costs associated with it. Usage costs quoted for NRMM include the execution of OBS78B.

POINT OF CONTACT

U.S. Army Tank-automotive and Armaments Command,
ATTN: AMSTA-TR-MTT, Mr. Peter Haley, Warren, MI 48397-5000
AC (810) 574-8633, DSN 786-8633

VEHDYNII

DESCRIPTION

VEHDYN II is a two dimensional pitch plane motion rigid frame vehicle dynamics model which is used to generate the ride quality curves of a vehicle traveling over continuous surface roughness terrain and discrete obstacles. The output is used as part of the input to the main module vehicle data set of NRMM.

USES

VEHDYNII is a stand alone module of the NATO Reference Mobility Model (NRMM). Its uses are the same as NRMM.

VEHDYNII is an engineering model (constructive type) which is used to develop the ride quality performance of a vehicle. The suspension, mass and inertial property engineering characterization of the vehicle are defined and the ride quality over surface roughness and discrete obstacles is determined. This information is then used within the main module of NRMM to limit speeds based upon whole body human vibration over the geographic regions within the NRMM terrain data bases.

CURRENT FEATURES

Wheeled or Tracked Vehicles
Prime Movers
Wheel/Tire Enveloping Algorithms
Suspension Component Hysteresis
Standard Suspension Types
Strictly Managed
Vehicle Data Development Program

CURRENT LIMITATIONS

Two Dimensional Simulation
Single Unit Vehicle Systems
Fixed Time Step Integration
No Powertrain Influence
Simplified Track Tension Algorithm

INPUT REQUIREMENTS

Vehicle Geometry
Chassis and Suspension Masses and Inertias
Suspension Characteristics
Terrain Profiles

Discrete Obstacles

AVAILABLE OUTPUTS

Absorbed Power
Vehicle Masses State Variable Histories

COMPUTER REQUIREMENTS

Operational on TACOM's CRAY-2 Supercomputer.

COST TO USE/DEVELOP/MAINTAIN

VEHDYNII, as a stand alone module of NRMM, is a mature model and thus does not have any development costs associated with it. Usage costs quoted for NRMM include the execution of VEHDYNII.

POINT OF CONTACT

U.S. Army Tank-automotive and Armaments Command,
ATTN: AMSTA-TR-MTT, Mr. Peter Haley, Warren, MI 48397-5000,
AC (810) 574-8633, DSN 786-8633

ANNEX C

STRUCTURAL ANALYSIS

ABAQUS

DESCRIPTION

ABAQUS is a commercial multi-purpose finite element code with the capability to perform structural and thermal analyses that are linear, nonlinear, static, harmonic, or transient dynamic. It is supported by Hibbitt, Karlson & Sorensen, Inc., Pawtucket, Rock Island. ABAQUS provides a large library of element types and material models. Overall, ABAQUS can determine stress and/or temperature distributions given a detailed description of a component's geometry, material properties, and environment within a mechanical system.

USES

ABAQUS is an engineering model used to determine structural integrity and size components within a mechanical system.

CURRENT FEATURES

Ease of use.
Complete consulting
Hotline services
Element Types:
All standard elements for Linear, Static, Dynamic and heat transfer.
Specialized Elements For:
- Contact problems
- User Defined Elements
- Super Elements and Substructuring

Materials Available:
- Special Linear and Nonlinear
- Plastic Models
- Rate Dependent Creep Model
- Accoustic Models
- Visoelastic and Hyperelastic Models
- User Defined Material Laws

Procedures Available:
- Standard Static and Dynamic Analysis
- Buckling
- Heat Transfer
- Random Response

Many User Defined Capabilities

CURRENT LIMITATIONS

Needs a preprocessor
No fluid Analysis

INPUT REQUIREMENTS

Component Geometry
Material Properties
Loadings
Constraints
Temperature
Element Type
Procedures
User Defined Input

AVAILABLE OUTPUTS

Displacements
Stresses
Strains
Temperature Distribution
Eigenvalues
Mode Shapes
User Defined
Output

COMPUTER REQUIREMENTS

Operational on TACOM's CRAY-2 Supercomputer.

COSTS TO USE/DEVELOP/MAINTAIN

$ 5K/year (small engineering workstation) to $35K/year (Cray Supercomputer) depending on the type of computer and the analysis options desired. Currently at TARDEC, approximately $ 20K per year is spent for a Cray 2 and Silicon Graphics license.

POINT OF CONTACT

U.S. Army Tank-automotive and Armaments Command,
ATTN: AMSTA-TR-X, Mr. Kenneth Ciarelli, Warren, Michigan
48397-5000, AC (810) 574-6365, AV 786-6365

PATRAN

DESCRIPTION

PATRAN is an open-ended, general-purpose, 3D, integrated Computer Aided Engineering pre- and post-processor that links engineering design, analysis, and results evaluation functions.

USES

Pre-/post-processor to finite element packages.
Used in geometric modeling.

CURRENT FEATURES

Geometry construction, viewing and editing
Can except geometric info from IGES and Pro/Engineer
Finite element modeling (node and element generation)
Graphic display of analysis results
Hidden line removal
Interfaces with many finite element analysis codes
Color graphics
Interfaces with ANSYS, ABAQUS, NASTRAN, DYNA

CURRENT LIMITATIONS

Analysis package option not included in TACOM's copy

INPUT REQUIREMENTS

Component geometry
Material properties
Loadings
Finite Element types
Constraints
Temperature
Boundary Conditions

AVAILABLE OUTPUTS

Stresses/Strains
Reaction loads
Deflections
Temperature gradient
X-Y bar chart plotting
Contour plots

Deformation plots
Video animation of transient results
Light source shading

COMPUTER REQUIREMENTS

Operational on various UNIX workstations.

COST TO USE/DEVELOP/MAINTAIN

Cost to maintain: $70K/yr approximate.

POINT OF CONTACT

U.S. Army Tank-automotive and Armaments Command, ATTN: AMSTA-TR-X, Mr. Roberto Garcia, Warren, MI 48397-5000, AC (810) 574-5363, DSN 786-5363

P-FATIGUE

DESCRIPTION

P-Fatigue is a commercial software package that is used as one tool to predict the life time of a component or system.P-fatigue uses stress or strain distribution generated by a FEA (finite element analysis) to predict the fatigue life or the crack propagation rate given the stress distribution, the material properties and the input loads.

USES

It is designed to be used in engineering models, engineering simulators, war games if questions of durabillity or crack propogations arise in the models.

CURRENT FEATURES

Nominal stress life
Strain Life
Damage accumulation
Crack growth prediction
Damage/cycle histograms
Interactive plotting of stress-strain, stress-life, strain-life, load history, and other curves

CURRENT LIMITATIONS

Material database
Interactive fatigue design optimization
Fatigue analysis of welds
Some modules menu driven
PDA hotline support
Rainflow cycle counting
Meanstress corrections
Interactive pre-processor

INPUT REQUIREMENTS

Load history (external ASCII file, create using pre-processor or SAE load history data base provided)
Material properties (a large database of cyclic material properties is provided with P/FATIGUE)
Stress/strain distribution from finite element analysis (in PATRAN neutral file format)
Crack growth/geometry parameters

AVAILABLE OUTPUTS

Nominal stress life
Strain Life
Damage accumulation
Crack growth prediction
Damage/cycle histograms
Interactive plotting of stress-strain, stress-life, strain-life, load history, and other curves

COMPUTER REQUIREMENTS

Currently on a TARDEC Scientific Network.

COST TO USE/DEVELOP/MAINTAIN

It costs about $8500.00 a year

POINT OF CONTACT

U.S. Army Tank-automotive and Armaments Command, ATTN: AMSTA-TR-X, Milton Chaika, Warren, MI 48397-5000, AC (810) 574-5363, DSN 786-5363

PINSTRESS

DESCRIPTION

Up to the recent time of MISGUIDE development, PINSTRESS was a 2D program which had been developed to relate external loads on a track to its deflections and internal stress. It has now been made into a 3D model.

USES

The PINSTRESS model enables deflections, rotations and stresses to be calculated when an arbitrary pattern of forces and movement is given or alternately, forces, moments and stresses may be calculated when deflections and rotations are known. PINSTRESS I was a computerized analysis of a single-pin span modeled in a relatively simple way. It served to demonstrate that pin distortions are important to the performance of double-pin track. To improve the accuracy of the calculations, PINSTRESS II was developed with a more complex model. It still comprehended only one pin span, and was not computerized. In PINSTRESS III, the analysis was refined a bit further, and four of the PINSTRESS II models were combined to provide a simultaneous solution for the four interrelated spans comprising the connector assembly of a double-pin, double-row track link. PINSTRESS III was computerized because the computations had become almost prohibitively time consuming to do by hand. PINSTRESS IV was developed at the same time to perform a similar function for double-pin, single-row track much as the T-150, which has only two pin spans per connector assembly

CURRENT FEATURES

In-planes tangential stresses on pin
Out-of-plan perpendicular stress on
Incorporation of PINSTRESS into MISGUIDE
Excellent for checking strains (ergo, stresses measured by strain gages in the field)

CURRENT LIMITATIONS

None.

INPUT REQUIREMENTS

Geometry of pin, bushing and
connectors, shoe body, sprocket teeth
Masses of above
Elastic properties of above
Forces and moments applied to the
track shoes and end connectors

AVAILABLE OUTPUTS

Displacements and rotations of pins, track shoes, and end connectors
Plots of bending moments that are developed along the four pins
Shearing forces and bending stress at pin-connector junctions
PINSTRESS Output also provides printer listings of numerous deflections and forces together with transfer functions relating inputs and outputs for given geometries and materials

COMPUTER REQUIREMENTS

Operational on TACOM's CRAY-2.

COST TO USE/DEVELOP/MAINTAIN

Use costs (analyst man years) are paid by the customer organization for the study being performed.

POINT OF CONTACT

U.S. Army Tank-automotive and Armaments Command,
ATTN: AMSTA-TR-MTT, Mr. Mike Saxon, Warren, MI 48397-5000,
AC (810) 574-6034, DSN 786-6034

ANNEX D

SURVIVABILITY

Acoustic Detection Range Prediction Model (ADRPM)

DESCRIPTION

ADRPM is a computer model that predicts maximum acoustic detection distances of ground combat vehicles whose acoustic signature is known at a reference distance. Basically, it calculates the attenuation effects of distance, ambient noise, ground cover, terrain, atmospheric conditions, and detector characteristics and applies it to given source levels. The atmospheric conditions control a quasi-ray tracing attenuation routine. The model starts at a short distance and with each successive iteration, the distance is increased until the resultant calculated attenuated source level is below the ambient noise. Conversely, it can also calculate the signature of the source for a desired distance.

USES

The model has been fully developed as an engineering model.

CURRENT FEATURES

Low frequency detection limit of 40 Hz for human detectors and 10 Hz for non-human detectors
Range search termination criteria now based on integrated detection
Inhomogeneous atmosphere
Graphic oriented user interface
Detection problem arranged on the screen in the form of block diagrams

CURRENT LIMITATIONS

Because atmospheric conditions are so dynamic, any model of this type only gives approximate values. When used to study a group of vehicles or changes in one of the parameters (changing wind speed or detector height), excellent relative comparisons are provided.

INPUT REQUIREMENTS

Reference Distance
Self Noise of Source as 1/3 octave (10 Hz to 10kHz) spectrum
Background 1/3 octave Spectrum
Observor Efficiency
Source Height
Detector Height
Weather
Terrain

AVAILABLE OUTPUTS

Target Detection Distance or a 1/3 octave spectrum, depending on how the model is run.

COMPUTER REQUIREMENTS

ADRPM VII has been implemented on a 386/486 compatible machine using MS-DOS. It is also operational on a HP 380 UNIX workstation.

COST TO USE/DEVELOP/MAINTAIN

The model has been developed with $1 M of TARDEC monies over a 12 year period. The model is available from TARDEC at this time. If the user requests, the model is available with technical support from the subcontractor. Details will have to be worked out individually with BBN. The last time someone asked for this kind of support (in 1992), BBN was asking for $1.2 K per year.

POINT OF CONTACT

U.S. Army Tank-automotive and Armaments Command, ATTN: AMSTA-TR-S, Messrs. Cartwright and Shalis, Warren, MI 48397-5000, AC (810) 574-8635/8706, DSN 786-8635/8706

Acoustic Requirements Translation Model (ARTM)

DESCRIPTION

Acoustic Requirements Translation Model (ARTM)--The ARTM is an acoustic detection model for ground combat vehicles which can function in two modes. First, it can take an acoustic signature spectrum of a vehicle and predict the range at which it will become undetectable to various acoustic sensors. Second, and more importantly for new vehicle design, is ARTM's ability to take a desired non-detectability distance and generate an acoustic spectrum that cannot be exceeded to remain non-detectable at the specified distance.

USES

Training for the individual soldier
Concepts analysis of force development
Engineering models
Engineering simulators
Could provide important input to some wargames

CURRENT FEATURES

See description.

CURRENT LIMITATIONS

None.

INPUT REQUIREMENTS

Acoustic signature spectrum of a vehicle.

AVAILABLE OUTPUTS

Range at which vehicle will be detectable to acoustic sensors.
Predicts a non-detectable distance.

COMPUTER REQUIREMENTS

The model, currently in release 2.0, runs on an IBM-compatible personal computer running Windows 3.1.

COST TO USE/DEVELOP/MAINTAIN

License fee: not established at this time. Development: ~200K

POINT OF CONTACT

U.S. Army Tank-automotive and Armaments Command,
ATTN: AMSTA-TR-S, Ms. Teresa Gonda, Warren, MI 48397-5000,
AC (810) 574-5468, DSN 786-5468

Physically Reasonable Infrared Signature Model (PRISM)

DESCRIPTION

PRISM is a software program in that predicts the surface temperatures of and radiance values off of targets and backgrounds. The program has matured over 8 years and the next release will be version 3.2.

USES

Signature data can be provided for training for the individual soldier
Signature analysis is used in Concepts analysis of force development
Engineering level model
Signature data is provided for Engineering simulators and Wargames

CURRENT FEATURES

Predicts surface temperature for vehicles, and backgrounds.
Can be used for buildings or fuel tanks.

CURRENT LIMITATIONS

Uses isothermal facets.

INPUT REQUIREMENTS

Faceted vehicle model
Mass and area of facets
Material specific heat, emissivity & absorptivity
Weather data
Operating conditions

AVAILABLE OUTPUTS

Vehicle temperature maps at different times.
Time histories of facet temperatures.

COMPUTER REQUIREMENTS

VAX 750, VAX 8800, CRAY-2 or IBM AT.

COST TO USE/DEVELOP/MAINTAIN

$1500 one time license fee for users.
Developer has invested average $200K per year in improvements over last 5 years.

POINT OF CONTACT

U.S. Army Tank-automotive and Armaments Command, ATTN: AMSTA-TR-S, Ms. Terry Gonda, Warren, MI 48397-5000, AC (810) 574-5468, DSN 786-5468

RADIATED NOISE ESTIMATION SOFTWARE (RANES)

DESCRIPTION

The RANES model predicts the acoustic signature of wheeled and tracked combat vehicles based on analytical tools within the model and a data base of the components that make up the vehicle. The model has path algorithms from the component source to the outer skin of the vehicle that subsequently permits the atmospheric model, ADRPM to predict signature vulnerability to 1000 meters. Higher order of complexity atmospheric models can also be used to extend the prediction distance.

USES

The model is an engineering level model that can be applied in engineering simulators and other engineering models dealing with acoustic signatures.

CURRENT FEATURES

The model can provide stationary predictions for ground vehicles.

CURRENT LIMITATIONS

The model cannot predict signatures for moving vehicles at this stage unless it has measured track signature from track force test stands.

INPUT REQUIREMENTS

Measured and analytical data.

AVAILABLE OUTPUTS

The output is a table of 1/3 octave sound predictions anywhere along the path of the model.

COMPUTER REQUIREMENTS

HARDWARE:
Sun Sparc Workstation
Sun Sparc10 Computer System
32 MB RAM/Disk Storage
Color Printer
This is a stand along system at this time.

SOFTWARE:
The software has been written in LISP by BBN.

COST TO USE/DEVELOP/MAINTAIN

RANES has been developed with $630 K of U.S. Army monies. The funds have come from TARDEC and FSTC, with TARDEC contributing a slightly larger share. The RANES 2.0 version will be available in unvalidated form in 9/95. After validation, anyone in the U.S. Government(especially all the D.O.D. branches) can ask for the RANES model for a maintenance fee that is to be established by BBN. The fee is estimated as $3 K per year at this time.

POINT OF CONTACT

US Army Tank-automotive and Armaments Command,
ATTN: AMSTA-TR-S, Mr. Edward Shalis, Warren, MI 48397-5000,
AC (810) 574-8706, DSN 786-8706

TRACK

DESCRIPTION

TRACK predicts the radar cross section of targets and predicts the performance of radar-guided missile. As input, TRACK requires a description of the target in terms of radar scattering shapes: flat plates, dihedrals, trihedrals, ellipsoids and top hats. TRACK,written in the language C, runs on most Unix-based engineering workstation. At TACOM, TRACK runs on a Silicon Graphics Indigo computer.

USES

Concepts analysis of force development.
Engineering models.

CURRENT FEATURES

Concept or existing vehicles
Wide frequency range (.1 GHz - 100 GHz)
Linear or circular polarizations on transmit and receive
Coherent or incoherent RCS measurements
Approximates curved earth, multipath from ground plane, and near field effects
Target moves independent of radar in yaw, pitch and roll

CURRENT LIMITATIONS

Grass terrain only

INPUT REQUIREMENTS

Vehicle geometry
Electromagnetic Scattering properties of target:
- Surface scattering properties
- Surface correlation
- Material type
  - Metallic, dielectric, radar absorbing material

Description of Radar System employed by the seeker (i.e., frequency, polarization, antenna beam width)
Range

AVAILABLE OUTPUTS

Total RCS of target.
Statistical distributions of RCS values
Range profiles
Major Scattering centers

COMPUTER REQUIREMENTS

Operational on a UNIX system V2 or VAX ULTRIX or VMS 4.6 (or higher)

COST TO USE/DEVELOP/MAINTAIN

TRACK itself is free. But TRACK requires a special graphics editor, MAX, which costs $10,000.

POINT OF CONTACT

US Army Tank-automotive and Armaments Command, ATTN: AMSTA-TR-S, John Bennett, Warren, MI 48397-5000, AC (810) 574-7748, DSN 786-7748

TACOM THERMAL IMAGE MODEL
TTIM

DESCRIPTION

TTIM has been developed to provide a tool to assess vehicle survivability by displaying a simulated image of a vehicle as it would appear to an operator of a thermal imaging system under varying conditions. TTIM does not predict the thermal properties of a vehicle or it's background, but instead uses an actual (or modeled) complex thermal image scene radiance (or apparent temperature) map as an input and maps the atmospheric effects, battlefield effects, and sensor effects into the image pixel by pixel.

The model is menu driven and is very flexible. The parameters used in describing the atmospheric conditions, the sensor, and the smoke/obscurants can be changed easily to simulate any battlefield conditions. There are libraries in which the TTIM obscurant descriptions can be maintained for easy recall. TTIM is based on several different models which have become standards in the industry. The main ones being LOWTRAN7 for the atmospheric effects, ACTMAD for the battlefield smoke/obscurants, and for the sensor effects a module which is heavily structured around the Static Performance Model.

USES

Create images that can be used in training for the individual soldier
Used in Concepts analysis of force development
An Engineering level model
Images can be created for Engineering simulators
Data can be used in Wargames

CURRENT FEATURES

Accepts either calibrated radiance or apparent temperature map as input
Real time animations can be developed (using single frames)
Incorporates natural atmospheric effects (LOWTRAN7)
Simulates smoke/obscurants effects
Sensor and smoke/obscurant parameters can be saved in easily recalled libraries
3-D atmospheric effects
User friendly (menu driven)

CURRENT LIMITATIONS

Two-dimensional analysis.

INPUT REQUIREMENTS

scene radiance or apparenttemperature maps
Natural atmospheric effects as used by LOWTRAN7
Sensor parameters for various systems
Battlefield obscurant effects parameters describing munitions/ geometry

AVAILABLE OUTPUTS

TTIM outputs an image which simulates the display of an infrared sensor based on atmospheric, battlefield interactive analysis. Fast, interactive, results. Threat projectile shorlines from all angles of elevation. Graphical and tabular output.

COMPUTER REQUIREMENTS

UNIX or VMS. SGI workstations are a plus.

COST TO USE/DEVELOP/MAINTAIN

TTIM runs on many platforms. One time license fee is $1500.

POINT OF CONTACT

U.S. Army Tank-automotive and Armaments Command,
ATTN: AMSTA-TR-S, Mr. Thomas Meitzler, Warren, MI 48397-5000,
AC (810) 574-7530, DSN 786-7530

XPATCH

DESCRIPTION

XPATCH predicts the radar cross sections of targets and also predicts how a target would look to a synthetic aperture radar. XPATCH takes as input a file describing the target as a collection of flat plates. XPATCH runs on most Unix workstations, but its graphic user interface runs only on a Silicon Graphics workstation. At TACOM, we run XPATCH on a Silicon Graphics Indigo.

USES

Engineering models

CURRENT FEATURES

Graphics user interface out on Silicon Graphics workstations.

CURRENT LIMITATIONS

None.

INPUT REQUIREMENTS

Flat plate target description.

AVAILABLE OUTPUTS

See description.

COMPUTER REQUIREMENTS

Runs on most UNIX workstations.

COST TO USE/DEVELOP/MAINTAIN

The Air Force provides XPATCH free to qualified users.

POINT OF CONTACT

U.S. Army Tank-automotive and Armaments Command,
ATTN: AMSTA-TR-S, Ms. Teresa Gonda, Warren, MI 48397-5000,
AC (810) 574-5468, DSN 786-5468

ANNEX E

VEHICLE SUBSYSTEM EVALUATION TOOLS

AdvanSIM-1076
(DIGITAL SIMULATION SOFTWARE)

DESCRIPTION

AdvanSIM-1076 is a Digital Simulation software package for both general purpose and system-level simulation of electronic circuits. The system consists of an integrated design environment; schematic capture front end through the simulator engine. The schematic design software contains a hierarchical structure that allows for a top-down or bottom up design approach. The top-down approach allows designs to be partitioned into various blocks allowing designer to move from higher levels of abstraction to detailed implementation.

USES

For use in the simulation of electronic circuits.

INPUT REQUIREMENTS

VHDL
Electronic Circuit Netlist
Voltage
Current
Frequency

AVAILABLE OUTPUTS

VHDL
Voltage
Current

COMPUTER REQUIREMENTS

Intergraph CAD System

CURRENT FEATURES

Verify logic design. Identify and correct timing problems. Test pattern evaluation and test generation.

CURRENT LIMITATIONS

None

COST TO USE/DEVELOP/MAINTAIN

Unavailable.

POINT OF CONTACT

U.S. Army Tank-automotive and Armaments Command, ATTN: AMSTA-TR-P, Ms. Jacqueline Walter, Warren, Michigan 48397-5000
AC (810) 574-6690 AV 786-6690

C SPICE
(ANALOG SIMULATION SOFTWARE)

DESCRIPTION

C Spice is an analog simulation software package for both general purpose and system-level simulation of electronic/electrical circuits. The system consists of an integrated design environment; schematic capture front end through the simulator engine. The schematic design software contains a hierarchical structure that allows for a top-down or bottom up design approach. The top-down approach allows designs to be partitioned into various blocks allowing designer to move from higher levels of abstraction to detailed implementation. Analog analysis includes a broad line of pre and post simulation tools including filter synthesis, circuit stability, pole/zero analysis, root locus, and two-port analysis. The results are shown in a graphical format. Modeling of components can be done in black box format using a descriptive language or constructed of electronic circuit components.

USES

The software can be used for board or system design/analysis.

CURRENT FEATURES

Produce simulations of DC Voltage, AC Frequency Transient Behavior, Analyze of Noise, Distortion and Sensitivity.

CURRENT LIMITATIONS

None

INPUT REQUIREMENTS

Electronic Circuit Netlist From ACEPLUS Schematic Software
SPICE Netlist
Voltage
Current
Frequency
Device Models

AVAILABLE OUTPUTS

Voltage
Current
Transient Behavior
Bode Plot
Pole/Zero Diagram

COMPUTER REQUIREMENTS

Intergraph CAD System

COST TO USE/DEVELOP/MAINTAIN

Unavailable.

POINT OF CONTACT

U.S. Army Tank-automotive and Armaments Command, ATTN: AMSTA-TR-P, Ms. Jacqueline Walter, Warren, MI 48397-5000, AC (810) 574-6690, DSN 786-6690

KIVA-II

DESCRIPTION

KIVA-II is a code for the simulation of chemically reactive fluid flows with liquid sprays. It is primarily intended for the simulation of piston engines and turbine combustors, and is not a general purpose CFD code.

USES

Simulation of piston engines and turbine combustors.

CURRENT FEATURES

Handles nearly all relevant processes of the closed portion of an internal combustion engine cycle in a spatially resolved way.

CURRENT LIMITATIONS

Does not handle open portions of cycle, i.e. intake and exhaust, though limited in and outflow options are available.
Very little output that allows direct comparison with engine test data or simpler but more comprehensive engine cycle simulations such as TRANSENG. Custom post processors are being written to provide this.

INPUT REQUIREMENTS

Cell Network (simplified for typical engine geometry).
Engine speed (may be set to 0).
Timing of events (fuel spray, optional spark ignition, etc.).
Boundary and Initial Conditions, incl initial chemical species density, temperature, turbulence, bulk motion etc.
Description of kinetic and equilibrium chemical reactions.
Description of fuel spray, incl droplet size, velocity, with options for breakup and coalescence models.

AVAILABLE OUTPUTS

Two and Three dimensional plots of computational grid, and gas velocity vectors, and spray drop locations.
Contour plots of normal velocity pressure, bulk density, temp, kinematic viscosity, turbulence kinetic energy and length scale, droplet sauter mean radius, fuel/air equivalence ratio, concentration of all species, etc.

COMPUTER REQUIREMENTS

KIVA-II is currently operational on the CRAY computer. Use on other machines is not recommended as the code was written to take advantage of CRAY architecture.

COST TO USE/DEVELOP/MAINTAIN

Money is given to the University of Wisconsin to perform diesel engine research and part of that money is towards development of Kiva - approximate cost is $7500 yearly.

POINT OF CONTACT

U.S. Army Tank-automotive and Armaments Command, ATTN: AMSTA-TR-M, Mr. Peter Schihl, Warren, MI 48397-5000, AC (810) 574-5796 DSN 786-5796

MISGUIDE

DESCRIPTION

MISGUIDE is a large scale digital simulation program which can predict misguiding of track (i.e., track throwing) on a tank due to side-loads such as while ditch crossing while sharp turning on cross-country at speed. The program extends all of the 2-dimensional capacity of TRACKDYNE into three dimensions and allows for the additional simulation of tank roll and yaw, while allowing for the 3-dimensional study of side loads on the track by including the lateral interaction of the track relative to the roadwheels and to the ground surface.

USES

To predict misguidining of track on a tank.

CURRENT FEATURES

Only program in existence that can look at track misguiding and its mechanism.
Diagnostic capability
Plots make process of misguiding easily visable and understandable
Allows for design improvements to prevent misguiding; thus, a tool for designer
Animation Output Available

CURRENT LIMITATIONS

Does not consider wetness, mud or stones between track and sprocket and track and roadwheels. Ergo, cannot simulate some very important real life conditions leading to track-throwing. At present considers friction drive of track sprocket. The next step in this work should be the integration of the TRACKDRIVE program into MISGUIDE so that the drive sprocket-track interaction is accurately represented.

INPUT REQUIREMENTS

All of the input parameters of TRACKDYNE with the addition of:
Track-ground interface via an algorithm whereby the forces and movements resulting from road pad-planar surface interference can be calculated.
The shape of the pad's "footprint" can be described by any polygon by no more than ten sets of coordinates locating corners of the polygon.
The rubber in the pads is described by a combination of linear and square wave springs and viscous and dry dampers. Spring and

damping constants are specified separately for the normal and tangential directions.
Each centerguide is assumed to have two prongs, each prong having two faces. Each centerguide face is modeled as consisting of spherical tip, comnical corner that tapers from the sphere to a point part way down the outer corner of the prong and two lines of possible contact that complete inner and outer boundaries of the face of the prong.
The PINSTRESS program was used as one of the foundation stones of the MISGUIDE program. It was converted from 2-D to 3-D
Unlike TRACKDYNE, MISGUIDE is written to accept curved surfaces, and any reasonable ground contour of unlimited complexity can be specified. The ground contour is specified which may contain collection of mathematical functions or a look-up Vehicle Control: sprocket rpm on the near side and sprocket torque on the off side

AVAILABLE OUTPUTS

New plotting routines were developed to enable the user to obtain a better understanding of the complex interaction of vehicle and track. The plots include a pictorial view of the vehicle showing the relative positions of the suspension and track parts, a set of curves showing the variation of track related force during one pitch passage cycle, and a set of curves showing the movements of the suspension over a period that may be as long as five pitch passage cycles.
The plotting code was organized as a separate program that utilizes a data file written by MISGUIDE. This allows repeated use of a given data file, as for pictorial views from different directions.
Progress over long runs can be monitored without the recording of excessive quantities of data. When an interesting event is observed, the appropriate part of the run can be repeated with full data output.
A generic ditch profile was devised
A decision can be made to vary tank speed and width of ditch until a combination is found which produce definite misguiding. Various design parameters of track and suspension can be changed to study their effect on MISGUIDE.
MISGUIDE incorporates an energy balance feature similar to that of TRACKDYNE which itemizes energy losses in the system and serves as a check on the correctness of the computations.

COMPUTER REQUIREMENTS

Operational on TACOM's Cray-2.

COST TO USE/DEVELOP/MAINTAIN

Use costs (analyst man years) are paid by the customer organization for the study being performed.

POINT OF CONTACT

U.S. Army Tank-automotive and Armaments Command,
ATTN: AMSTA-TR-MTS, Nancy Saxon, Warren, MI 48397-5000
AC (810) 574-5068, DSN 786-5068

TRACKDRIVE

DESCRIPTION

TRACKDRIVE is a three-dimensional dynamic simulation of a portion of a track loop including track on the sprocket and in approaching and leaving spans.

USES

The purpose of the program is to investigate the efficiency and smoothness of operation of the sprocket teeth as they engage the track, to evaluate stresses in the track structure as it passes over the sprocket, and to determine the circumstances that will lead to a tooth skipping event. Dry friction contact between the complex shapes of sprocket teeth and end connectors is modeled in detail, and this function comprises much of the TRACKDRIVE program.

CURRENT FEATURES

Enables full study of track/sprocket behavior three-dimensionally:
The only such program in existence

CURRENT LIMITATIONS

None, provided good data on pin, connector, shoe steel and rubber properties are given.

INPUT REQUIREMENTS

Number of pitch passage cycles to berun in this simulation
Hardware specification indicator
Initial condition source indicator
Calcomp plot indicator
Speed of track relative to hull
Torque applied to sprocket
Total tension to be maintained in track
Coefficient of dry friction between sprocket teeth and end connectors
Sprocket tooth geometry specification and moments of elasticity
Bushing end distances to plane of sprocket
Radial spring rate of bushing rubber
Viscous damping for bushing rubber
Number of track links in system

AVAILABLE OUTPUTS

Average velocity at the outgoing end of the track where tension is controlled
Horsepower transmitted to sprocket by final drive
Data (geometric) on track passage over sprocket
Data (moment, and total forces) transmitted to the sprocket by the track
Link parameters such as angular deflection of shoes, position and angular orientation of centerguide
Contact parameters of teeth with sprocket, such as location of normal to surfaces, and forces on end connectors
Energy balances
Pictorial diagrams
Plots of tension, pin stress, bending stress and bending moment in the structural bridge between shoes of Diehl-type track as they pass from entrance of the system to the exit
Contact force plot
Hull force and sprocket torque plots
Final conditions
Diagnostic Outputs

COMPUTER REQUIREMENTS

Operational on TACOM's Cray-2.

COST TO USE/DEVELOP/MAINTAIN

Use costs (analyst man years) are paid by the customer organization for the study being performed.

POINT OF CONTACT

U.S. Army Tank-automotive and Armaments Command,
ATTN: AMSTA-TR-MTS, Wesley Bylsma, Warren, MI 48397-5000,
AC (810) 574-6133, DSN 786-6133

TRACKDYNE

DESCRIPTION

TRACKDYNE is a two-dimensional dynamic simulation program of an entire track loop, including vehicle suspension, hull dynamics, and interaction of the track with a road surface. Only one side of the vehicle is simulated. When calculating hull motions, it is assumed that both sides are undergoing the same events. The action of the sprocket is simplified by treating it as a traction drive into the rubber of the track rather than as a toothed drive into the end connectors.

USES

Track performance evaluation.

CURRENT FEATURES

Time "frozen" plots of track enabling study of standing waves
Numerical data on HP losses in bushings, pads, sliding contact, road friction, roadwheels and idler
Energy dissipated by dampers
Well documented
Extensive validation effort completed.
Animation Output Available.

CURRENT LIMITATIONS

Two dimensional simulation; ergo,
two sides "see" implicitly the same
Sprocket simulated as a friction drive rather than toothed drive
No roll or yaw

INPUT REQUIREMENTS

Shock absorber specification
Support roll specification
Chassis and suspension masses and inertias
Vehicle mph; and rate of change
Drawbar pull; and rate of change
Walk coefficient
Geometry of vehicle and track, links, shoes, pins
Tractive effort
Road gradient and terrain specification
Setting of adjusting link in compensating linkage
Static preload tension in track
Suspension characteristics and attitude
Rubber deformation
Number of cycles for which full data are to be printed, and energy balance is to be performed

AVAILABLE OUTPUTS

Program estimates final drive rpm
Final drive torque required
Data may be printed for all cycles
Each cycle is summarized by a single line
Calcomp plots: pictorial representation of track, suspension and road
Area of the footprint is printed
Average HP in and out
Station data which are pitch passage cycles
Hull parameters: horizontal and vertical position, an acceleration and velocity of c.g. in world coordinate system.
Pitch angular acceleration, angle and pitching angular velocity of hull
Shoe parameters
Tension in track
Wheel parameters: sprocket, support rolls, idler, and road wheels, around circuit

COMPUTER REQUIREMENTS

Operational on TACOM's Cray-2.

COST TO USE/DEVELOP/MAINTAIN

Use costs (analyst man years) are paid by the customer organization for the study being performed.

POINT OF CONTACT

U.S. Army Tank-automotive and Armaments Command,
ATTN: AMSTA-TR-MTS, Nancy Saxon, Warren, MI 48397-5000,
AC (810) 574-5068, DSN 786-5068

ANNEX F

SYSTEMS AND COST

Combined Arms and Support Task Force Evaluation Model CASTFOREM

DESCRIPTION

Proponent: TRADOC TRAC-WSMR. CASTFOREM provides high-resolution force-on-force combat effectiveness analysis.

USES

This model is used to support the Tank-Automotive Research, Development and Engineering Center (TARDEC) and PM-Survivability Systems combat vehicle designers. It is used to optimize suites of survivability enhancing technologies and other vehicle characteristics. The model is also used to train new CASTFOREM modelers. The model requires a Sun Workstaion to run.

CURRENT FEATURES

Direct fire ground weapon systems.
Helicopters.
Dismounted infantry.
Artillery.
Engineering operations
CSS functions.
Communications.
Maneuver with route selection.
Detailed search and acquisition.
Realistic battlefield.

CURRENT LIMITATIONS

Limited TACAIR.
Limited NBC warfare.
No EW.
No vehicular battlefield dust.

INPUT REQUIREMENTS

Battlefield terrain.
Force sizes and structures.
Inventory of:
- Weapons
- Sensors
- Communication devices, etc.

Tactics.
Initial force locations.
Road network.
Battle positions.
Tactical areas.
Decision tables.

AVAILABLE OUTPUTS

Model yields:
- History files of unit actions
- Decision table audits

For Processor Yields:
- Ammo expenditures
- Aspect angle
- Artillery accuracy
- Artillery queuing
- Coincidence statistics
- Commander kills
- Direct energy negations
- Engineer events
- Firers
- Impacts
- Integrity of unit positions
- Kills/range
- Laser damage
- MCP moves
- M/F/C kills
- Moves
- Net usage
- Plots on losses
- Recorded detections
- Rounds
- Search times
- Smoke
- Targets
- Unit summary

Graphical Playback of Battle

COMPUTER REQUIREMENTS

Developed and runs on a VAX with a SIMSCRIPT II.5 compiler. Graphics option requires a RAMTEK display terminal and interface.

COST TO USE/DEVELOP/MAINTAIN\

Development and maintenance are handled by the proponent organization - TRADOC. Use costs (analyst man years) are paid by the customer organization for the study being performed.

POINT OF CONTACT

US Army Tank-automotive and Armaments Command,
ATTN: AMSTA-RM-VSM, Michael Kerr, Warren, MI 48397-5000,
AC (810) 574- 6819, DSN 786-6819

DISTRIBUTION SYSTEM ANALYZER MODEL

DESCRIPTION

Models how various types of cargo are moved to and on the battlefield using a road network, trucks, trailers, loading docks, and materiel handling equipment.

USES

Can be used to quantify the impact which any change to the cargo delivery system has on meeting battlefield requirements for resupply. For example, DSA can estimate the effect of tech insertions, vehicle upgrades, new procurements, newements, new types of equipment, improved communications, or changes in warfighting or logistics doctrine.

CURRENT FEATURES

Models trucks in terms of cubic and weight capacity for carrying cargo, reliability, time to repair, and speed on each part of the road network (which includes trails and cross-country segments).

CURRENT LIMITATIONS

Can model only 20 types of trucks at one time.

INPUT REQUIREMENTS

Demands for resupply generated by an ongoing battle; layout of road network, sources of supply, supply transfer points, and fighting units; kinds, numbers, assignments, and tech data for all transportation assets; logistics relationship of fighting units and supporting units.

AVAILABLE OUTPUTS

Detailed and voluminous output files contains: supply demands/deliveries by type and receiving unit; usage data for each truck and each portion of the distribution system.

COMPUTER REQUIREMENTS

IBM-compatible 386 PC, 4MB RAM, DOS 3.1 or higher

COST TO USE/DEVELOP/MAINTAIN

Development completed at more than $100K.

POINT OF CONTACT

US Army Tank-automotive and Armaments Command, ATTN: AMSTA-TR-L, Bob Daigle, Warren, MI 48397-5000, AC (810) 574- 6703, DSN 786-6703

GROUNDWARS

DESCRIPTION

Proponent: AMSAA. Groundwars is primarily used to evaluated weapon system effectiveness. The model can address ammunition expenditures, acquisition delivery accuracy, vulnerability, lethaility rate of fire, disengagement policies, effect of line of site due to terrain or obscurants and it effect of various round types (e.g., KE, HEAT, command to line of site, fire and forget, or near simultaneous engagement type missiles)

USES

This model is used to support the Tank-Automotive Research, Development and Engineering Center (TARDEC) and PM-Survivability Systems combat vehicle designers. It is used to optimize suites of survivability enhancing technologies and other vehicle characteristics. The model is also used to train new Groundwars modelers.

CURRENT FEATURES

Stochastic dynamic, event driven model.

CURRENT LIMITATIONS

Groundwars has no graphics. It simulation has very limited play of artillery, and currently has no play of air systems or mines. The total number of combatants, attackers & defenders combined cannot exceed one hundred.

INPUT REQUIREMENTS

Not applicable.

AVAILABLE OUTPUTS

Enhance output with the aid of graphics.
Other organizations benefit from the model by utilizing the results of the studies performed by this organization.

COMPUTER REQUIREMENTS

The model will run on a PC, CRAY-2 or Silicon Graphics.

COST TO USE/DEVELOP/MAINTAIN

Development and maintenance are handled by the proponent organization - AMSAA. Use costs (analyst man years) are paid by the customer organization for the study being performed

POINT OF CONTACT

US Army Tank-automotive and Armaments Command, ATTN: AMSTA-RM-VS, Michael Kerr, Warren, MI 48397-5000, AC (810) 574-6819, DSN 786-6819
AMSAA POC: US Army Materiel Systems Analysis Activity, ATTN: AMXSY-GC, Mr. Barry Burns, Aberdeen Proving Ground, MD 21005-5071, AC (410) 278-7289, DSN 298-7289

MAINTENANCE EXPENDITURE LIMIT (MEL) MODEL

DESCRIPTION

Computes the economic Useful Life and the economically optimum MEL vs. age for life cycle managment of a fleet of essentially similar trucks (Ex., 5 Ton fleet). Runs on most PC's. Highly mathematical model which converges to optimum solution after many iterations. Helps identify at what level of repair or age, funds could be better spent on procuremnt of new vehicles rather than continued maintenance of old.

USES

Enables TACOM to comply with the AMC reg to publish economically sound MEL guidance to the field.

CURRENT FEATURES

Also can be used to:
  Evaluate alternative MEL policies input by the user.
  Evaluate various vehicle resale policies.
  Evaluate costs of allocating vehicles in different age groups to various Active Army and Reserve rolls.

CURRENT LIMITATIONS

Input data:
  Number of maintenance incidents, cost per maintenance incident, and the variance and standard deviation of these values must not decrease with vehicle age.
  Maintenance incident variance should not be more than 3 times the mean.

Assumptions:
  Fleet size is constant.
  Fleet age structure has settled down.
  Policy will continue to operate and is rigidly enforced.
  Vehicles are replaced by like vehicles.
  Vehicles are immediately replaced after disposal

INPUT REQUIREMENTS

Major inputs are:
  Vehicle replacement cost
  Mean number of unscheduled maintenance incidents at vehicle year of life 1.
  Mean number of unscheduled maintenance incidents at vehicle year of life x*,

Variance of number of unscheduled maintenance incidents at vehicle year of life 1.
Variance of number of unscheduled maintenance incidents at vehicle year of life x*.
Mean cost per unscheduled maintenance incident at vehicle year of life 1 and x*.
Standard deviation of unscheduled maintenance incident cost at vehicle year of life 1 and x*.
* Generally x=10.

AVAILABLE OUTPUTS

Listing shows for each year of life:
- The Optimum MEL
  - % of fleet which would survive under that MEL.
  - Fleet distribution.
  - Expected number of maintenance actions per year.
  - Expected maintenance cost per year.

Also shows for this MEL policy:
- Expected length of life (with variance).
- Mean age of the fleet.
- Median age of the fleet.
- Partitioning of costs by:
  - New buys.
  - Repair labor costs.
  - Repair parts cost.

COMPUTER REQUIREMENTS

SIMSCRIPT and FORTRAN versions of the model operational on TACOM's CRAY. FORTRAN version also operational as executable file for personal computers. AMSAA has versions in other languages (ALGOL).

COST TO USE/DEVELOP/MAINTAIN

Assuming the required input data are available, requires about 2 man-weeks per fleet analyzed.

POINT OF CONTACT

US Army Tank-automotive Command, ATTN: AMSTA-TR-L, Bob Daigle, Warren, MI 48397-5000, AC (810) 574- 6703, DSN 786-6703

MANAGEMENT STRATEGY MODEL
(MSM)

DESCRIPTION

Modernization Strategy Management (MSM) model is a Linear Progr amming model that optimizes TWV fleet modernization (effectiveness) over a 20 year period, given an annual budget and yearly vehicle parameters.

USES

Provides analytical basis for TWV portion of Army Modernization Plan; used to develop/defend major TWV acquisition initiatives.

CURRENT FEATURES

Run-time is approximately 15 to 20 minutes on the hardware and software listed below (#7).

CURRENT LIMITATIONS

Detailed input must be provided. Data entry can be time-consuming. Investigation of infeasibilities, if they occur, can be time-consuming for the novice.

INPUT REQUIREMENTS

The following data is required by vehicle system and by year:

a. current inventory
b. bounds on procurement, unit procurement and fixed costs
c. unit operational and maintenance (O&M) costs
d. system effectiveness values vs. age
e. peacetime replacement factors
f. bounds on mission size requirements
g. forced retirements, if any
h. mission modernization requirements
i. procurement budget

AVAILABLE OUTPUTS

The following 20 year schedules are created by the model:

a. Procurement and retirement schedules and quantities
b. Projected yearly vehicle system and sub-fleet effectiveness

c. Annual cost projections for procurement, operating and maintenance

d. Annual inventories and average ages by vehicle system, and sub-fleet

COMPUTER REQUIREMENTS

486 PC with Quatro Pro and "industrial size" version of "What's Best", linear optimizer.

COST TO USE/DEVELOP/MAINTAIN

In the neighborhood of $40,000 to $50,000. Software costs were approximately $5,000 and the remainder was the amount on a SAIC contract to bring it in-house from CAA (Concepts Analysis Agency), where it was called FOMOA and was used to study helicopters. Since it is PC based on computers in our office, cost for us to maintain is based on analyst's time to prepare the model for running. This varies according to the complexity of the scenario to be modeled.

POINT OF CONTACT

US Army Tank-automotive and Armaments Command, ATTN: AMSTA-TR-L, Carole Fischer, Bob Daigle, Warren, MI 48397-5000, AC: (810) 574-6704, DSN 786-6704, AC (810) 574-6703, DSN 786-6703

TECHNICAL DATA PACKAGE
(TDP)

DESCRIPTION

The TDP (Technical Data Package) Model calculates the life cycle loss, savings, or break-even cost of purchasing or developing a TDP for a Sole Source item. The model is a Lotus spreadsheet and can be run on any PC. We export the Lotus file to WordPerfect in order to produce output as DRXOM Form 126-1 (Modified), 1 Mar 76. Inputs include the unit cost of the item, the future procurement schedule of the item, the cost to develop a TDP (not necessary for a break-even study), a competition savings factor and discount factors.

USES

We most often use the model to justify sole source procurement of items for TARDEC's Components and Testing Team (AMSTA-TR-KE). We also use it for other TACOM offices to either justify sole source procurement or determine if purchasing a TDP suitable for full and open competition is cost effective.

CURREMT FEATURES

Calculates the break even cost of the TDP as well as the cost savings.

CURRENT LIMITATIONS

Can only calculate savings for 10 years.

INPUT REQUIREMENTS

Base Year of analysis.
Number of years covered by the analysis.
First year of procurement.
Cost of the TDP development.
Unit cost of the item.
Additional nonrecurring cost.
Discount rate.
Competition savings factor.
Learning curve parameters.
Production schedule.
Composite inflation indices.

AVAILABLE OUTPUTS

Potential Competition savings cost.
TDP net potential savings.
Return on investment.

COMPUTER REQUIREMENTS

IBM PC/XT or AT (or compatible with 5.25 disk drive).

COST TO USE/DEVELOP/MAINTAIN

It doesn't cost anything outside of analyst salaries. In time, a study takes about two hours, and the number of studies per year can range anywhere from twenty to two hundred.

POINT OF CONTACT

US Army Tank-automotive and Armaments Command, ATTN: AMSTA-RM-VSM, Dennis Bjoraker, Warren, MI 48397-5000, AC (810) 574-8688, DSN 786-8688.

WARRANTY COST ANALYSES MODEL (WARCAMpc)

DESCRIPTION

WARCAM was developed at TACOM as an improvement on the Warranty Analysis Model (WARM) developed by AVSCOM. WARCAM compares the cost of a warranty with the costs of the no-warranty options. The expected savings from purchasing the warranty is given.

USES

Using inputs about the number of vehicles, the usage rate, the MUBF, and repair costs, the model calculates the expected value and cost-effectiveness analyses of a given warranty. Each warranty requires about 10 runs of the model, as sensitivity of some of the input values is checked.

CURRENT FEATURES

Failure free Threshold, and Systemic Warranties. Finite vs Infinite Failures per item. Calculates time when threshold is reached. Sensitivity analysis on the warranted MUBF.

CURRENT LIMITATIONS

Item oriented - Costs and MUBF for systems must be computed manually before development of costs and MUBF for components interactive.

INPUT REQUIREMENTS

Economic life of item
Delivery schedule:
  Items
  Spares
Excalation indices
Warranted Mean Usage Between Failure (MUBF)
MUBF range:
  Low MUBF
  High MUBF
  Median MUBF
  Step size (for ranging)
MUBF factors
Discount rate
Inherent Failure rate
Valid claim rate
GS-level repair rate
Repair costs for warranty option:
  Warranted failures
  Non warranted failures

Exclusions Contractor's Liability Limit
Post warranty failures
Repair costs for no warranty
Warranty limits (time & usage)
Warranty type (failure free/threshold/systemic)
Failure threshold
Maximum failure rate
Failure per item limit (0 - infinite)
Time units (years/months)
Distribution type for MUBF
(Triangular/Weibull)

AVAILABLE OUTPUTS

Expected number of failures at warrantied MUBF
Break out of costs at warrantied MUBF
Distribution of failures at the warrantied MUBF
For each step through range of MUBF's:
- Cumulative probability of not exceeding that MUBF
- Expected number of warranted failures and of all failures.
- Cost estimates for the warranty and no warranty options.

Expected value of the warranty
Cumulative probabilities for:
- Costs under warranty
- Costs for no warranty options.

COMPUTER REQUIREMENTS

The Warranty Cost-Analysis Model (WARCAMpc) is written in TurboPASCAL 5.0 and runs on a PC. It's an adaptation of the WARCAM written for the Prime computer, in FY77.

COSTS TO USE/DEVELOP/MAINTAIN

Approximately $1,300 per study in analyst and data gathering time. Since the types of warranties have become fairly standard, no significant maintenance effort is required. This model is not authorized for use at other Army installations.

POINT OF CONTACT

U.S. Army Tank-automotive & Armaments Command, ATTN: AMSTA-TR-VSM, David Grant, Warren, MI 48397-5000, AC: (810) 574-8698, DSN: 876-8698

ANNEX G

MANUFACTURING

Virtual Factory Simulation Software

DESCRIPTION

This software provides 3D workcell and factory floor simulation. The software has extensive libraries of existing machines and robots and provides for concept, design, and process verification as well as off-line programming and real-time bilateral control of remote robot and device controllers. All levels of manufacturing control can be simulated. Additionally, interactive visualization of all simulations is provided and immersion into the simulated prototyping/factory environments is also possible. Results of process simulations, once verified, can be directly downloaded to the factory floor for execution.

USES

This software is used to model existing or planned prototyping or manufacturing facilities and simulate machine, workcell, and/or process flow of vehicle components, sub-assemblies, or entire vehicle systems. This allows potential problems in component manufacture and assembly process flow to be indentified and corrected early on in the engineering design phase prior to any metal being cut, formed, or assembled.

CURRENT FEATURES

Interactive Visualization, Adaptable to many Virtual Reality hardware pieces; with a VR menu interface available as an option.

CURRENT LIMITATIONS

Numerical Control interfaces have to specifically written for each VIRTUAL machine that is to be NC capable to EXACTLY imitate the ACTUAL machine.

INPUT REQUIREMENTS

Machine and/or Robot Geometry and functional characteristics (once entered can be saved to library for future reference/re-use) and logical flows or assembly sequence (can be "tweaked" or optimized to find best-flow procedures).

AVAILABLE OUTPUTS

Simulation data times, costs (electrical/machine wear/replacement/maintainence), logic flows, etc. can be stored to files for thorough review/adjustments. Simulation can be saved to video animation. Computer screen can be saved or printed in many popular still graphic formats.

COMPUTER REQUIREMENTS

Any UNIX-capable workstation (Silicon Graphics, InterGraph, Hewlett-Packard, Sun, etc.)

COST TO USE/DEVELOP/MAINTAIN

The software costs approximately $30K per year to maintain.

POINT OF CONTACT

U.S. Army Tank-automotive and Armaments Command, ATTN: AMSTA-TR-P, Mr. Robert Washburn, Warren, MI 48397-5000, AC (810) 574-6690, DSN 786-6690

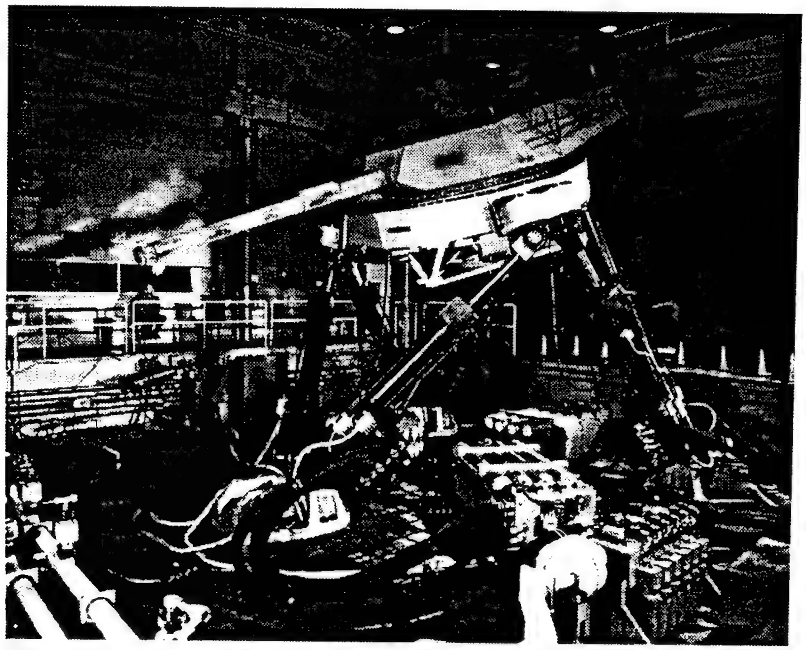
ANNEX H

SIMULATORS

CREW STATION/TURRET MOTION BASE SIMULATOR (CS/TMBS)

DESCRIPTION:

The Crew Station/Turret Motion Base Simulator is a six degree of freedom (DOF) test device capable of replicating terrain-induced dynamic inputs on actual turret systems and crew stations. These turret systems can range from 0 to 25 tons and can be operated by human crews.



USES

The CS/TMBS is currently used to perform duty cycle testing (particularly off-road) of large combat vehicle subsystems (e.g., turrets) and gun-turret drive stabilization systems, and will soon be capable of performing high-fidelity man-in-the-loop, soldier-machine interface studies after installation of a computer generated imagery (CGI) system.

CURRENT FEATURES

Will accomodate up to 25 ton payload.
The CS/TMBS is a manrated system.
Realtime simulation using CS/TMBS and vehicle system feedback.
Handles MANPRINT issues.
Safety systems include active and passive backup.
Self diagnosis of event failures.
Motion performance covers wide range of vehicle/terrain scenarios.
Full six degree of freedom motion base.

CURRENT LIMITATIONS

No Computer Generated Imagery system for crew station.
Software and control algorithms not fully defined for heavy active turret systems.
Vehicle CS/TMBS interface issues not completely resolved.
Moving Target Simulator not available.

INPUT REQUIREMENTS

Desired vibration environment.
Tank mass, inertial, and geometric properties.
High Speed Simulation
Math model describing vehicle/terrain dynamics.
Physical Hardware to be tested.
Operational scenario and test plan.
Vehicle CS/TMBS interface characteristics and components.

AVAILABLE OUTPUTS

Gun/turret drive weapon stabilization performance assessments.
Crew station man/machine interaction dynamic displays and control measurements.
Validation/proof-of-principle assessment of subsystems and components.
Implementation and evaluation of modern control strategies.

COMPUTER REQUIREMENTS

Self contained system consisting of harris 5800 Nighthawk simulation computer and several microprocessor based controllers and safety monitor computers connected to TARDEC's supercomputer network.

COST TO USE/DEVELOP/MAINTAIN

Approximately $50K is required to keep the laboratory in a ready state. This includes yearly re-occurring costs, cost of replacement of expendable items and costs for non-expendable items. The cost to use this simulator varies on a case by case basis depending upon test scenario, test preparation and special fixturing requirements.

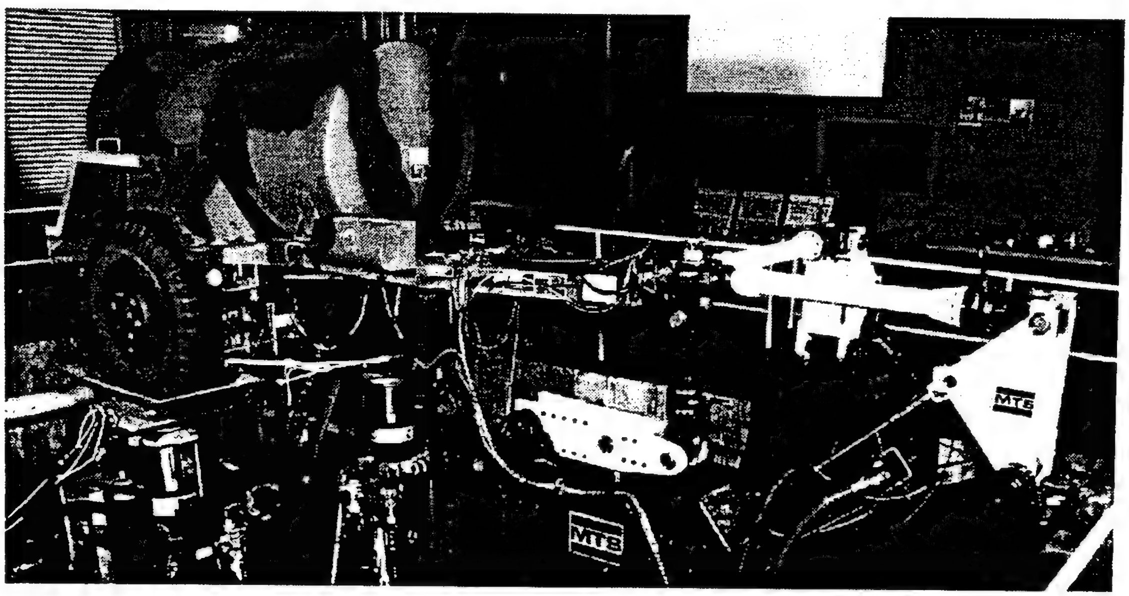
POINT OF CONTACT

U.S. Army Tank-automotive and Armaments Command, ATTN: AMSTA-TR-X, Mr. Harry Zywiol, Warren, MI 48397-5000, AC (810) 574-5032
DSN 786-5032

PINTLE MOTION BASE SIMULATOR
(PMBS)

DESCRIPTION

A Pintle Motion Base Simulator is a 5 degree of greedom testing device capable of reproducing terrain-induced dynamic inputs on lunette trailers weighing up to 20,000 pounds. The PMBS is capable of inputting motion, in three simultaneous directions, into the lunette of the attached trailer and inputting vertical motion into each wheel of the attached trailer. The PMBS therefore control the significant force inputs that are normally experienced by a trailer when tranversing a rough terrain. The PMBS uses an advanced control system called Remote Parameter Control™ (RPC). RPC allows the simulator to control accelerations and strains located at points on the trailer itself.



USES

Durability and performance testing of lunette trailers.
Testing of the structural road worthiness of design prototypes and/or modified fileded systems.
Determine the viability of suspension, frame, or payload modifications.
Measuring the vibration environment a payload would be subjected to if mounted on a new trailer.
Prototype testing in a iterative design or trouble shooting process.

CURRENT FEATURES

Test up to 20,000 pound trailers.
Motion inputs into the trailer lunette in three directions.
Vertical motion input to each wheel.
Verified to produce accurate results to 40 Hz.
Test a wide variety of trailers on multiple terrain/speed scenarios.
Capable of testing single or double axle trailers.
Capable of testing tracked trailers.
Uses Remote Paramater Control™ as the control system.
Has ability to record 40 instrumentation channels.
Has powerful post-test anaysis software.

CURRENT LIMITATIONS

Cannot test fifth-wheel trailers.
Requires trailer response data (either field or computer model derived) to perform a test.
Requires a pre-test iteration process prior to the start of a durability or performance test.
Computer model may introduce errors.
Cannot currently simulate a constant (DC) longitudinal load on the lunette.

INPUT REQUIREMENTS

Physical hardware to be tested.
Desired vibration environment (terrains & speeds).
Instrumentation requirements.
Trailer mass and dimensional characteristics.
Computer based model of the trailer system or field response data.
Test plan.

AVAILABLE OUTPUTS

Trailer dynamic response data (e.g. acceleration, displacement, rotational rates, and strain) in statistical, data plot, or electronic format.
Post-test analysis of recorded data including PSDs, statistics, histograms, and transfer functions.
Durability assessment of modifications and design prototypes.
Formal report detailing the test and summarizing recorded results.

COMPUTER REQUIREMENTS

Self contained, dedicated system consisting of a VAXstation 3100 M48 host computer.
A stand alone, real-time drive command generating, data acquisition, and signal monitoring computer.

COST TO USE/DEVELOP/MAINTAIN

Approximately $50K is required to keep the laboratory in a ready state. This includes yearly re-occurring costs, cost of replacement of expendable items and costs for non-expendable items. The cost to use this simulator varies on a case by case basis depending upon test scenario, test preparation and special fixturing requirements.

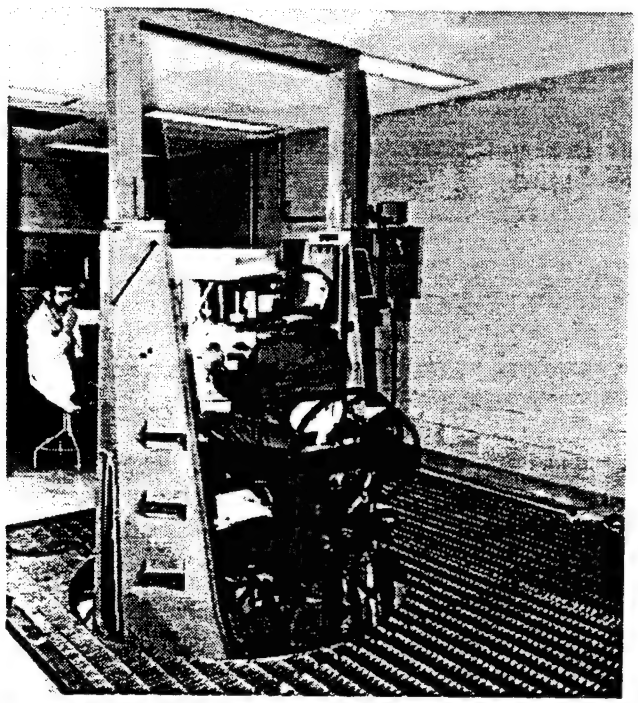
POINT OF CONTACT

U.S. Army Tank-automotive and Armaments Command, ATTN: AMSTA-TR-X, Mr. Mark Brudnak, Warren, MI 48397-5000, AC (810) 574-6676 DSN 786-6676

RIDE MOTION BASE SIMULATOR
(RMS)

DESCRIPTION

The Ride Motion Base Simulator is a four degree-of-freedom (vertical, roll, pitch, and yaw) single-person, simulator capable of reproducing the ride dynamics of any Army land-based vehicle. A wide range of vehicles, bump courses, and seatings (gunners, commanders, drivers) can easily be simulated and recreated on the RMS.



USES

The platform is large enough to allow simulation of a crew station, or to simply evaluate a seating configuration. Investigations can be conducted on human tolerance to vibrations in general, or task performance in a vibrational environment. The RMS has currently been used to evaluate bio-dynamic influences of certain crew-machine interfaces for advanced technology crew stations. The RMS was configured with 2 driver controllers and 2 head-mounted displays (HMDs). A subject operated a controller/HMD combination while undergoing static, periodic, and simulated combat vehicle dynamic motion.

CURRENT FEATURES

The RMS is a manrated system.
The RMS has real-time CAMAC/MicroVAX control.
The RMS has eight pneumatic fail-safe devices, two shut-down switches on the CAMAC, plus electronic travel limiters to protect humans from injury and valuable components from damage. Motion performance covers wide range of vehicle/terrain scenarios.

CURRENT LIMITATIONS

No Computer Generated Imagery system for crew station.
Bandwidth limitations - vertical: 6 Hz, Yaw: 1 Hz, Pitch: 10 Hz
Stroke length limitations.

INPUT REQUIREMENTS

Desired vibration environment.
Math model describing vehicle/terrain dynamics.
Physical hardware to be tested.
Operational scenario and test plan.

AVAILABLE OUTPUTS

Implementation and evaluation of modern control strategies.
Validation/proof-of-principle assessment of subsystems and components.
Crew station man/machine interaction with dynamic controllers and Helmet Mounted Displays (HMDs).

COMPUTER REQUIREMENTS

In the current configuration, the input signals are generated from computer data files created on a CRAY-2 supercomputer using computer simulation of an Army vehicle operating over specific bump courses. These files are then modified and used to drive the RMS using a micro-VAX II computer. A Computer Automated Measurement and Control (CAMAC) computer system acts as an interface between the micro-VAX II computer and the RMS. Data files stored on the micro-VAX II determine the terrain profile, vehicle, and speed the RMS will simulate.

COST TO USE/DEVELOP/MAINTAIN

Approximately $10K is required to keep the laboratory in a ready state. This includes yearly re-occurring costs, cost of replacement of expendable items and costs for non-expendable

items. The cost to use this simulator varies on a case by case basis depending upon test scenario, test preparation and special fixturing requirements.

POINT OF CONTACT

U.S. Army Tank-automotive and Armaments Command, ATTN: AMSTA-TR-X, Ms. AnnMarie Berger, Warren, MI 48397-5000, AC (810) 574-6676 DSN 786-6676

VETRONICS SIMULATION FACILITY (VSF)

The VCDD has been renamed the VSF.

DESCRIPTION

The VETRONICS Simulation Facility (VSF) is a key component in the US ARMY's Tank-Automotive Research, Development, & Engineering Center's (TARDEC) Virtual Prototyping Process. The VSF is used for the rapid prototyping and evaluation of crew stations, and vehicle concepts. The VSF consists of hardware/software reconfigurable crewstations capable of representing different vehicles, Computer Generated Forces (CGF) for friendly and threat vehicles, and a Stealth/Plan View station for viewing the battle which all interact in a computer generated world. The VSF is capable of running stand-alone at TARDEC or being linked long haul via the Defense Simulation Internet (DSI) with other defense simulator such as Battlefield Distributed Simulation-Developmental at Ft. Knox, the Aviation Testbed at Ft. Rucker and/or the Crew Station Research & Development Facility at NASA Ames. The VSF is currently a fixed based simulator, but plans are under way to build VSF Cabs that would fit on TARDEC's Turret Motion Base Simulator (TMBS) a six-degree of freedom motion platform.

USES

Engineering simulators
Distributed Interactive Simulation (DIS) Simulator
Virtual Simulator
Used for Research & Development
Engineering Level, One-on-One Level, Many-on-Many and/or Few-on-Few Level
Used to evaluate Soldier Machine Interfaces

CURRENT FEATURES

Future Tank - available currently
Bradley A2+ - available currently
Bradley A3 - available 3rdQTR FY95
Future Tank (2,3,4 person configurations) - 1stQTR FY96

CURRENT LIMITATIONS

Simulator has no motion
Only two crew stations (which can be configured as either commanders, gunners or drivers station)
No force on force

INPUT REQUIREMENTS

See Description.

AVAILABLE OUTPUTS

See Description.

COMPUTER REQUIREMENTS

OFF THE SHELF SOFTWARE

SOLDIER MACHINE INTERFACE:
VAPS - Virtual Prototypes, Montreal, Canada
Designers Workbench - Coryphaeous Software, Los Gatos, CA
COMPUTER GENERATED WORLD:
GVS - Gemini Visual Systems, California
Performer - Silicon Graphics Inc
TERRAIN DATABASE DEVELOPMENT:
Multigen - Software Systems, California
SOUND SYSTEM:
Audioworks - Paradigm, Texas
CONFIGURATION MANAGEMENT:
ClearCase - Silicon Graphics (Atria)

VSF DEVELOPED/MODIFIED SOFTWARE

INTER-PROCESS COMMUNICATION
PROCESS INTERFACE UNIT - TACOM DEVELOPED
INTER-COMPUTER COMMUNICATION
PROCESS INTERFACE UNIT - TACOM DEVELOPED
DISTRIBUTED INTERACTIVE SIMULATION (DIS) COMMUNICATION
Network Interface Unit (NIU) - TACOM Developed
VEHICLE MODELS
FIRE CONTROL SYSTEM - TACOM Developed
MOBILITY - SIMNET CODE MODIFIED
VULNERABILITY - TACOM DEVELOPED
COMMAND & CONTROL SYSTEM - TACOM DEVELOPED

VSF HARDWARE:

COMPUTERS
Silicon Graphic Inc (SGI)
ONYX RACK SYSTEMS (3)
Four 150MHz R4400 Processor
Two Reality Engine2 Graphic Pipes
One Multi-Channel Option
Ethernet, FDDI
Hard Drive: 2-GigaByte
RAM: 256 MBytes
ONYX DESKSIDE (2)

Four 150MHz R4400 Processor
One Reality Engine2 Graphic Pipes
One Multi-Channel Option
Ethernet, FDDI
Hard Drive: 2-GigaByte
RAM: 256 MBytes
SKYWRITER Reality Rack System (1)
340 VGX (1)
310 VGX (1)
Indigo (2)
Personal Iris (2)

Defense Simulation Internet Node
Stealth System
Computer Generated Forces

COST TO USE/DEVELOP/MAINTAIN

USE: This is determined by defining the task and then adding up the cost (which includes the following):

- VETRONICS PERSON YEAR COST (currently $100K per year)
- Additional off-the-shelf software
- Additional off the shelf hardware
- Computer Time

DEVELOP: This is determined by defining the task and then adding up the cost (which include the following):

- VETRONICS PERSON YEAR COST (currently $100K per year)
- Additional off-the-shelf software
- Additional off the shelf hardware
- Computer Time

POINT OF CONTACT

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